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Yukon Forest Health Report

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This report summarizes the findings of the annual forest health survey conducted throughout the month of July, 2008. The purpose of the survey was to provide an annual assessment of forest pest activity throughout the southern Yukon with particular emphasis on the ongoing spruce beetle infestation in the southwest. This year's survey included, in addition to the annual aerial survey to assess spruce beetle mortality, an aerial survey along the Yukon River south of Dawson City to further assess and map white spruce mortality and a flight along the North Klondike Highway between Whitehorse and Stewart Crossing to map eastern spruce budworm and pine needle cast. Roadside surveys were conducted along the Alaska Highway between Watson Lake and Beaver Creek, the Haines Road, the North and South Klondike highways, the Dempster Highway as far as Km 225, the Mayo Road and the Robert Campbell Highway between Carmacks and Little Salmon Lake.

Among pests encountered during the survey were: spruce beetle, *Dendroctonus rufipennis*, spruce engraver, *Ips perturbatus*, fir-spruce budworm, *Choristoneura orae*, eastern spruce budworm, *C. fumiferana*, pine engraver, *Ips pin,I,* pine needle cast, *Lophodermella concolor,* aspen serpentine leafminer, *Phyllocnistis populiella* and willow blotch miner, *Micrurapteryx salicifoliella*.

The Yukon experienced a relatively normal winter with January temperatures sufficiently cold to cause some mortality of overwintering spruce beetle larvae within the Shakwak Trench. Most of the mortality occurred in low-lying areas subject to the pooling of cold air. A cool spring was followed by an unusually cool and wet summer that delayed and dispersed the emergence of adult beetles, further compromising an already falling population.

White Spruce Pests

Spruce Beetle

The area containing recent white spruce mortality fell to 5000 ha (Map1), less than half of the area mapped in 2007, and an eighth of the 2006 total. The reduction occurred despite the fact that it was the result of the "peak" flight which occurs every second year involving the 'on-cycle" portion of the population. This phenomenon of larger flights in the odd year is due to the spruce beetle normally following a two year life cycle, and, despite the occurrence of periodic one-year cycling in the climatically favorable years, the bulk of the population remains in the original sequence, maturing in the odd year. The halving of mapped mortality is, therefore, more significant. Any prognosis on the future of the infestation must however, be made using the most current population data, which, in this case, is the pheromone trap data described below.

Pheromone trapping

For the fourth consecutive year, pheromone traps were deployed during the spruce beetle flight period to enumerate the emerging adult population (see Map 1 and Table 1). Additional traps were set this year at the Dimok mill site at Canyon, and at a firewood log depot just north of the North Klondike Hwy junction, to trap any beetles that might emerge from the log piles. The two right-hand columns in Table 1, comparing this year's trapping results to last year's, show a 44% reduction in the number of trapped adults at the 20 primary trap locations. The reduction was expected because 2007 was the "on-cycle" year for the two-year cycle population. Despite the reduction, however, this year's numbers showed that spruce beetle populations have not yet collapsed and served to illustrate the surprising resilience of this infestation as well as the ongoing susceptibility of the remaining host white spruce, years after the end of the drought which initiated the infestation in the early 1990s. In some areas it also reflected the increased role of the engraver beetle *Ips perturbatus*. Populations of this secondary beetle have increased throughout the duration of the infestation. Initially they were able to successfully colonize and breed within the trees that had been overcome by spruce beetle. That success increased the population to the extent that they were able to initiate successful attacks on their own.

Ips perturbatus is not known to be strongly attracted to the spruce beetle pheromone, (a specifically formulated *I. perturbatus* pheromone is commercially available). Individuals that appeared in the traps (Table 1 in brackets) are therefore thought to be incidental, having blundered into the traps by chance. This suggests that a large number of beetles were flying and supports the data from the stand assessments (Table 2) that, at least along the highway corridors east and south of Haines Junction, where the spruce beetle infestation is in a senescent phase, the *I. perturbatus* population is now as large, or larger, than the remaining population of spruce beetles.

Tree-by-tree assessments

These assessments were made at approximately 10km intervals east of Haines Junction as far as Champagne to track the eastward advance and assess the health of the infestation. Between 50 and 100 trees >20cm in diameter were tallied at each site and their condition with respect to beetle attack recorded (Table 2).

Current attacks, at 1.5%, were the lowest ever recorded, and less than half of them were attributed to spruce beetle alone. The rest were either a mixture of spruce and engraver beetles or engraver beetles alone. In most of the currents, attack was initiated by *Ips*. A small number of spruce beetle attacks were seen near the base of many of these trees, indicating that the two species have recently undergone a role reversal, with the spruce beetle now relying to some degree on the engraver beetle to provide breeding opportunities. This having been said, a large majority of the area of currently active infestation is in the Dezadeash River valley north of Dezadeash Lake and east of Dezadeash Lake toward Kusawa Lake as well as near Jo-Jo Lake (see Map 1). Though these areas are not accessible by road and no ground assessments were done, these infestations are relatively new and active and presumed to be overwhelmingly spruce beetle driven.

Table 1. Spruce Beetle Pheromone Trap Catches 2008

Trap No.		Geographic co-ordinates	week 1	week 2	week 3	week 4	week 5	week 6	Totals 2007	Totals 2008
28	Km 1428 Alaska Hwy.	8 433365 6737267	0	0	32	11	5	1	18	50
24	Km 1.3 Medenhall Tower Rd.	8 441628 6738414	4 (Ips)	0	0	1 (10 Ips)	0	0	3	1
23	Km 1514 Alaska Hwy.	8 436353 6736375	0 (11Ips)	0	6	2	1	1	3	10
22	Km 1495 Alaska Hwy.	8 419822 6742854	0	0	0	4	25	4	48	33
21	Km 1528 Alaska Hwy.	8 406854 6743375	2	0	9	7	3	9	36	30
20	Km 1535.8 Alaska Hwy.	8 398291 6743525	0	0	0 (150Ips)	0 (52 Ips)	1 (10 Ips)	2	3	2
19	Km 22 Aishihik Lake Road	8 387334 6657427	17 (22 Ips)	3	18 (59 Ips)	13 (70 Ips)	4 (36 Ips)	5	147	60
18	Km 10 Aishihik Lake Road	8 389981 6787898	0	0	2	1	2	1	2	6
17	Km .1 Aishihik Lake Road	8 389565 6748439	0 (80 Ips)	1	0	1 (61 Ips)	2 (14 Ips)	0 (23 Ips)	22	4
16	Km 1557.4 Alaska Hwy.	8 359004 6747720	4	1	16	10	4	2	7	37
15	Km 1567.3 Alaska Hwy.	8 368887 6744544	2	2	3	0	0	0	5	7
14	Haines Jct. Airport Road	8 362790 6741339	0	0	14	0	0	0	2	14
13	10 km east of H.J. Muffin	8 370774 6743057	12	0	13	4	2	1	10	32
27	Km 243.4 Haines Road	8 364070 6736799	7 (8 Ips)	2	15	5	7	3	15	39
12	Km 240 Haines Road	8 367784 6735019	1	0	36	1	12	1	6	51
26	Km 234.5 Haines Road	8 371120 6729204	0	0	74	24	15	3	284	116
11	Km 228 Haines Road	8 373759 6724570	1	0	320	16	4	0	575	341
10	Km 206 Haines Road	8 386718 6707582	4	0	173	56	39	54	534	326
9	Km 189 Haines Road	8 387097 6691099	0 (129 Ips)	0	2	0	1	0	3	3
25	Km 182 Haines Road (Klukshu)	8 388906 6685513	0	1	36	11	45	2	511	95
29	Dimok millsite (Hwy side)	8 388405 6748508	0	0	2	2	0	0	no trap	4
30	Dimok millsite (forest side)	8 388475 6748259	2	0	2	9	8	5	no trap	24
Mayo Rd H	stored firewood logs	8 491138 6755512	0	0	0	0	0	0	no trap	0
Mayo Rd F	stored firewood logs	8 490815 6755456	0	0	0	0	0	0	no trap	0
						totals (paired locations only)			2234	1257

Table 2. Tree-by-tree assessments 2008

Plot no.	Location	UTM[1] Zone	UTM[1] Easting	UTM[1] Northing	% of trees Healthy[2]	Current	Red	Grey	Partial	Pitch-out
1	10 km -E- Haines Junction	8	368051	6743782	29	0	0	57	14	0
2	20 km -E- Haines Junction	8	376966	6747107	51	2	0	41	7	0
3	30 km -E- Haines Junction	8	385685	6748460	36	7	3	29	24	0
4	36 km -E- Haines Junction	8	391922	6747318	75	0	4	19	2	0
5	40 km -E- Haines Junction	8	395955	6744750	57	0	0	28	15	0
6	50 km -E- Haines Junction	8	405532	6743082	96	0	0	4	0	0
				average	57.3	1.5	1.2	29.7	10.3	0

[1] Universal Trans-Mercator grid system

[2] Healthy - not attacked
Current - killed by spruce and/or Ips beetles in current year
Red - attacked the previous year
Grey - attacked two or more years previously
Partial - attacked but not killed
Pitch-out - attacks repelled by tree

Like last year, red trees (ones that had died the previous year) were hard to find in areas accessible by road. Being an important indicator of spruce beetle population condition they were examined wherever they were found. Almost every red tree exhibited a different sign of beetle engagement. In some trees, characteristic gallery patterns and exit holes indicated a successful *Ips* attack in 2007. Almost no spruce beetle progeny were found in any red trees. Some contained successful parent galleries but no brood galleries. Some larvae had been killed by winter cold and some had suffered predation.

The main predator that has been observed within the infestation is a member of the family Cleridae – the checkered beetles. Commonly called Clerids, both the adult beetles and larvae (Photo 1) prey on beetle adults and progeny respectively. Both spruce beetles and engraver beetles are preyed upon. At the height of the infestation in the mid-to-late 1990s, they had little or no effect, but as the infestation waned and Clerid populations increased, the ratio of predator to prey increased to such a degree that, recently, they have likely become a significant population control agent.

The scene from the air

In the third week of July a two day aerial survey was undertaken to map all stands containing red tress killed by beetles (either spruce beetle or *Ips* engraver beetle) the previous year. Unfortunately, bad weather south of Klukshu prevented the survey of stands along the Klukshu River, Blanshard River, the upper Tatshenshini River and the Takanne River south of Howard Lakes. However, little mortality was mapped here in 2007 and ground surveys indicated that there was even less mortality in 2008.

Unless otherwise stated, all mapped infestations were light in intensity (10% or less of overstory stand trees (all species) attacked the previous year).

Beginning in the northeast, no recent attacks were seen along the lower Aishihik River near Emery and Seven Mile creeks where a total of 500 ha was mapped in 2007. At the confluence of the Aishihik and West Aishihik rivers, just north of the diversion canal, mortality was similar to last year with numerous small patches; two of moderate intensity, totaling about 200 ha.   To the north, 10 scattered polygons of light mortality were mapped along the north side of the West Aishihik River, ending about eight km. south of Bear Lakes. Two of the larger attack polygons, totaling about 250 ha in size, were in immature stands and therefore likely engraver beetle attacks. Unlike last year no mortality was mapped along the south side of the West Aishihik. Scattered small patches, many containing 10 trees or less, occurred along Bear Lakes and along both sides of Sekulmun Lake as far north as Isaac Lake. There were no attacks north of the mouth of Isaac Creek and no attacks within the Isaac Creek drainage. Farther west within the Gladstone River drainage, no mortality was mapped for the first time in many years.

Continuing west to Kluane Lake, attacks continued along both sides of Talbot Arm at the same locations as last year but the overall area of attack was about half. Numerous small polygons were again mapped along both sides of Raft Creek.

Farther south no new attacks were seen until, just west of Sulphur Lake, six scattered small polygons were mapped in immature stands and were attributed to engraver beetles. Three small patches also caused by engraver beetle were seen just northwest of Haines Junction, near Bear Creek. From here to Quill Creek only scattered small groups of red trees were seen near the Haines Junction Airport and just south of town on the slopes of the Ariol Range. Just south of Quill Creek and between here and Kathleen Lake, five polygons totaled about 400 ha, similar to 2007, though this year much of the mortality was in immature stands and almost certainly caused by *Ips*. More *Ips* damage, probably with the aid of spruce beetles, occurred on the east-facing slopes of the Dalton range just west of

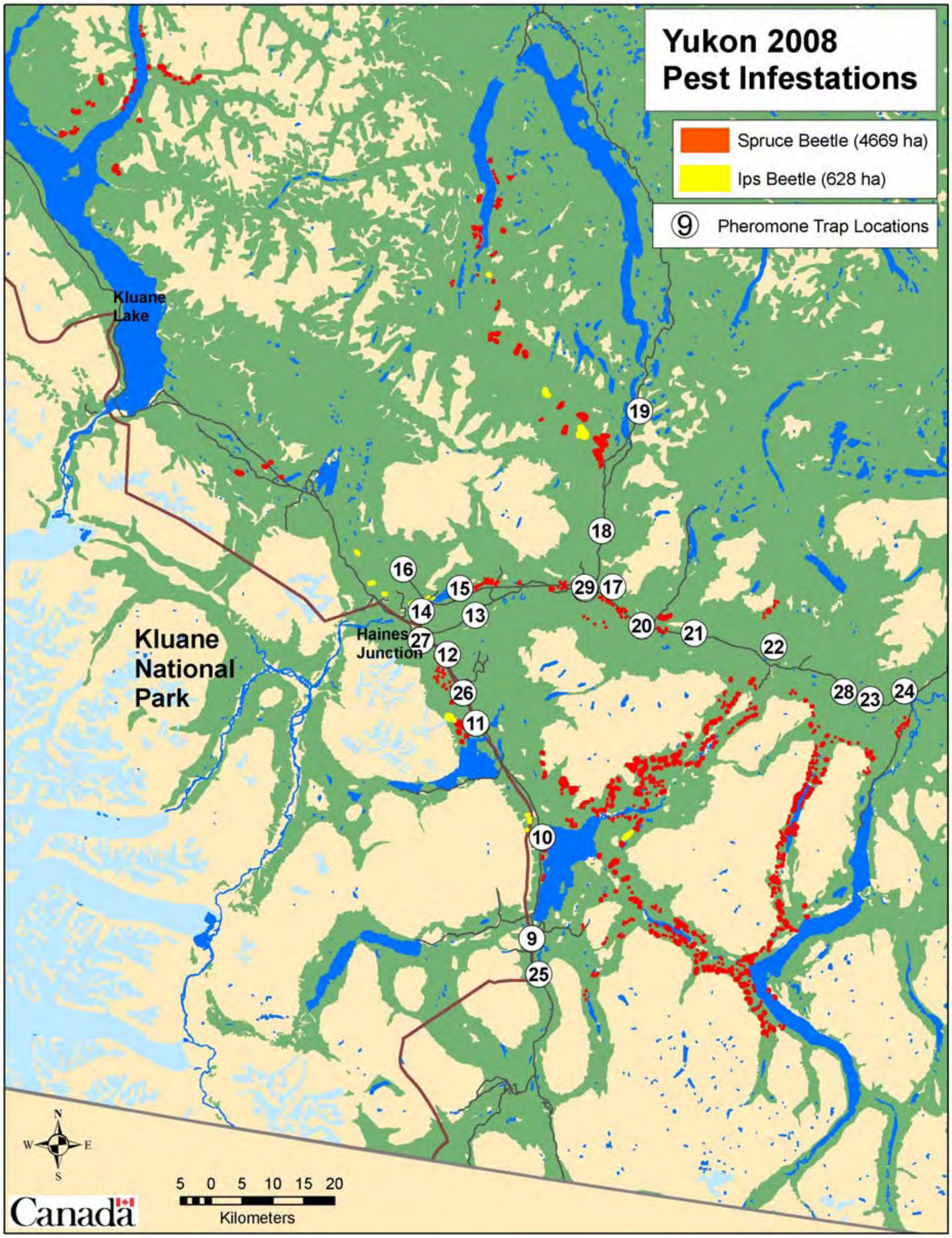
Dezadeash Lake. A little farther south, numerous small groups of dead trees were seen between the Haines Road and the Lake.

Photo 1. Clerid beetle larva under the bark of spruce attacked by engraver beetles

The areas east of Dezadeash Lake across Frederick Lake to Kusawa Lake, north through the Jo-Jo Lake pass and along the Dezadeash River between Dezadeash Lake and Champagne housed the bulk of the infestations mapped in 2008. Infestations in these valleys account for an estimated 80 percent of the remaining spruce beetle populations in the southwest Yukon. Dead trees were mapped in over 170 separate polygons of 5+ ha with an equivalent number of small groups of 10 trees or less. The mapped area of mortality in these areas was only slightly less than last year and the intensity of attacks was essentially the same with all but a few polygons rated as light. The only difference from last year was 10 new small patches of mortality on the north-facing slope between the north end of the pass leading to Jo-Jo Lake and the north end of Kusawa Lake. In the same area, just south of Mendenhall Landing numerous single and small groups of trees were killed by engraver beetles that successfully bred in blowdown and then began attacking healthy spruce trees.

Between Champagne and Haines Junction most of the mortality was confined to scattered small groups of trees, most of which lay along both sides of the Alaska Highway corridor. Minor concentrations occurred on the east slope of a hill directly north of Champagne and on the east side of lower Cracker Creek. Many of the trees, particularly those along the Highway, were killed by *Ips* with some spruce beetles in the lower boles.

Map 1. Recent spruce mortality caused by spruce beetle and engraver beetle



Spruce beetle in Tombstone Park

Earlier in the year park rangers at Tombstone noticed beetle-killed spruce along the Grizzly Trail just west of the Tombstone Campground. In mid July the stand was assessed during the annual survey of stands along the Dempster Highway. Eight hundred meters from the trail head three grey standing trees were found, all of which had been killed by spruce beetle about three years ago. However, the small infestation had died out after the initial attacks. It was almost certainly initiated in adjacent blowdown which also showed signs of attack. Blowdown is historically the most common cause of spruce beetle outbreaks. The second largest recorded infestation (after the Shakwak) in the Bowron River drainage south of Prince George which, at its height, covered more than 80 000 ha, was initiated in 1979 by blowdown. The small recent outbreak followed the more typical pattern of single event initiation, by being unable to maintain the role of primary attacker of healthy trees after the initial cycle of buildup in the blowdown.

Spruce engraver beetle, *Ips perturbatus*

Ips perturbatus infestations were more common and widespread this year than at any other time since forest health records have been kept. Engraver beetle infestations were mapped over a total of 628 ha (Map 1) during aerial surveys in the southwest and an additional 2546 ha in scattered infestations along the Yukon River and tributaries south of Dawson City (Map 2). Elsewhere, scattered smaller infestations followed industrial and climatic events that provided breeding host for the opportunistic beetle.

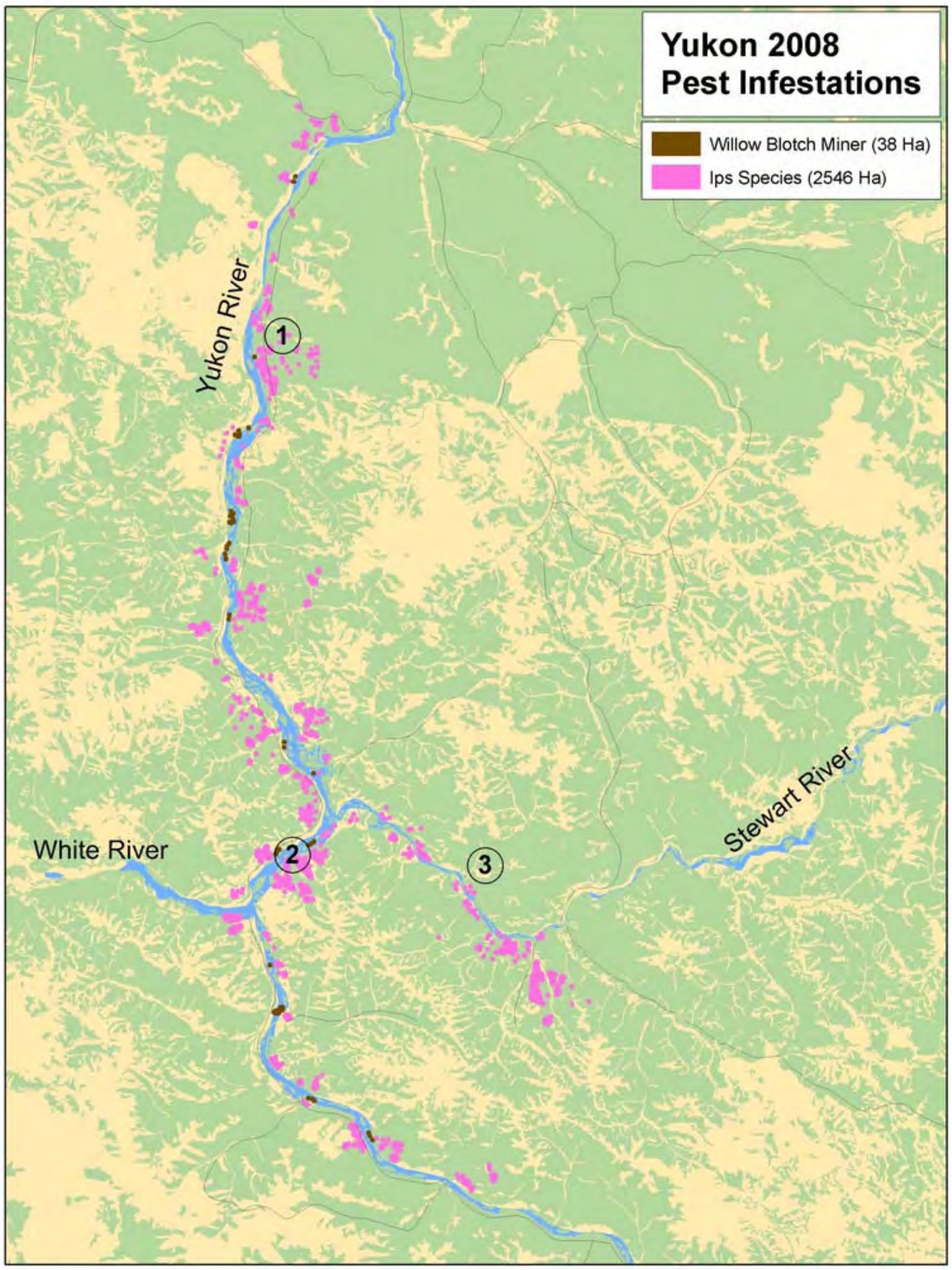
In the southwest the mortality occurred in stands of immature spruce and was presumed to be exclusively *Ips*-caused. Many of these patches of immature trees are scattered over the landscape; the legacy of a patchy low frequency wildfire regime. Most are less than 100 ha in size and many have been selectively hit by the high populations of *Ips* beetles for which they are the favoured host. All other infestations mapped in the southwest in 2008 were designated as spruce beetle, but, especially east and south of Haines Junction, in stands where spruce beetle populations peaked between five and ten years ago, there was a significant often higher, *Ips* component.

Dead and dying white spruce were first seen along the Yukon River in July 2007 and assessed on the ground in October. The primary cause of mortality following four successive warm and dry years was determined to be drought. At that time the availability of susceptible host outstripped the local secondary beetle populations and many of the dead trees remained unattacked. When the area was flown in late July of this year the number of red crowns had increased significantly, and mortality was mapped over an areas of 2546 ha. Ground assessments were made at three locations (see Map 2):

1. Indian River. Grey trees seen from the air were initially thought to have been attacked in 2006 or earlier. Ground checks confirmed that they were attacked last year by *Ips* and the trees were so drought stressed that needle drop occurred quickly. An equivalent number of adjacent trees were currently attacked but no broods had been produced. A few unsuccessful spruce beetle attacks were seen at the base of a few *Ips*-attacked trees.

2. Frisco Creek. Two grey trees werekilled by *Ips* in 2007; one with many exit holes (successful broods), the other with none. No current attacks were seen. There was no evidence of spruce beetle involvement.
3. Stewart River. We were only able to land the helicopter on a gravel bar beside the river where there was a small patch of dead trees. The majority of the mortality was higher on the hill. All grey trees were killed by *Ips* in 2007. There were very few exit holes and no current attacks. A few spruce beetle pupae were found below the root collar on one tree.

Map 2. Areas where *Ips perturbatus* mortality and *Micrurapteryx salicifoliella* defoliation were mapped along the Yukon River and tributaries.



A planned return to the Stewart River area to build helicopter landing pads and provide us with access was prevented by bad weather. Chad Dyce of Yukon Forest Management returned in August to build the pads and he and Rob Leguere from Whitehorse Forest Management did the subsequent ground survey. They found much the same situation as in the other areas. Many trees were attacked by *Ips* in 2007 with little spruce beetle involvement. No current attacks could be found. The poor brood production will likely limit the ongoing mortality and the unusually wet summer has effectively ended the drought, so the scattered infestations are not expected to continue past 2009.

Many current- and red- (2007) attacked trees were seen along the forest fringes on both sides of the North Klondike Highway near McQuesten. Populations in this area have been high for some years due to right-of-way clearing, first for a power line and, more recently, the widening of the highway corridor. Populations first built in slash associated with the cutting of trees for the power line and then moved into adjacent living fringe trees that were stressed by their recent exposure at the forest edge. This pattern was repeated with the subsequent highway widening only the base beetle population was much greater, and many fringe trees have been killed. Red trees were also seen along the power line right-of-way across the Stewart River from Stewart Crossing. This small infestation is a remnant of one that has been killing fringe trees for the past three years. In another common infestation-causing scenario, recent blowdown near Km 6.5 of the Kusawa Lake Road provided host material to build *Ips* populations that subsequently attacked and killed five adjacent healthy trees. A similar infestation involving a related species of engraver beetle is described below in the Pine Pests section of the report. These types of secondary beetle infestations normally last for a few years and inevitably collapse when the supply of susceptible host is exhausted. They have not evolved to sustain a population in healthy trees and are normally overcome in a few generations by the mechanisms of tree resistance.

Elsewhere small engraver beetle infestations were encountered in a Fire Smart project at Canyon (discussed below in “Fire Smart”) and in trees killed by high water at Tagish (discussed below in “Flood Damage”).

Spruce budworm, Choristoneura spp.

Eastern spruce budworm, *Choristoneura fumiferana*

The eastern spruce budworm, *Choristoneura fumiferana*, has long been known to inhabit white spruce stands in the interior of the Yukon, residing primarily in areas in and adjacent to the Tintina Trench which is a northern extension of the Rocky Mountain Trench. This year, light defoliation of white spruce was mapped from the air over an area totaling 1003 ha, near Stuart Crossing and in two small patches approximately 25 km south (Map 3) (Photo 2). Though budworm larvae had been collected here in the past, this was the first time that noticeable defoliation had been seen in this area. Historically eastern spruce budworm damage had been mapped in the extreme southeast at Irons Creek and in the LaBiche and Beaver River drainages. These infestations peaked in the mid 1990s.and subsided after 2000. Between 1998 and 2000, trace levels of defoliation were also seen in the vicinity of Km 50 of the Dempster Highway

Photo 2. Light defoliation near Stewart Crossing by the eastern spruce budworm.

In 2007, during an aerial ecological classification exercise within the Mackenzie River drainage, surveyors based out of Hay River, Northwest Territory reported apparent budworm defoliation in a white spruce stand adjacent to the Peel River (Photo 3), at approximately 66 degrees 40 minutes north latitude (B. Decker pers. comm.). If this, indeed, was the eastern spruce budworm the sighting would constitute a northern extension of its known range.

Fir-spruce budworm and two-year cycle budworm, *Choristoneura orae, C. biennis*

In 2002 spruce budworm moths were seen flying in significant numbers in the Kaskawulsh River Valley within Kluane National Park, and near the south end of Kluane Lake. The following year, branch samples with hibernating budworm were sent to the Pacific Forestry Centre for rearing. Under laboratory conditions the budworm from Kluane was found to have a two-year life cycle, entering a second hibernation cycle (diapause) as mid-instar larvae. Because there are two species of the genus *Choristoneura* (*C. biennis* and *C. orae*) that are morphologically similar and known to have a two-year life cycle, the species was not identified at the time. Fortunately, both of these species are known to respond to slightly different formulations of pheromone. In 2004 traps baited with a pheromone specific to each species of moth were placed at six locations along the Alaska Highway between Congdon Creek and the Donjek River. The traps baited with the *C. orae* pheromone captured almost three times as many moths as the *C. biennis* bait.

Map 3. Areas of light defoliation by the eastern spruce budworm near Stewart Crossing.

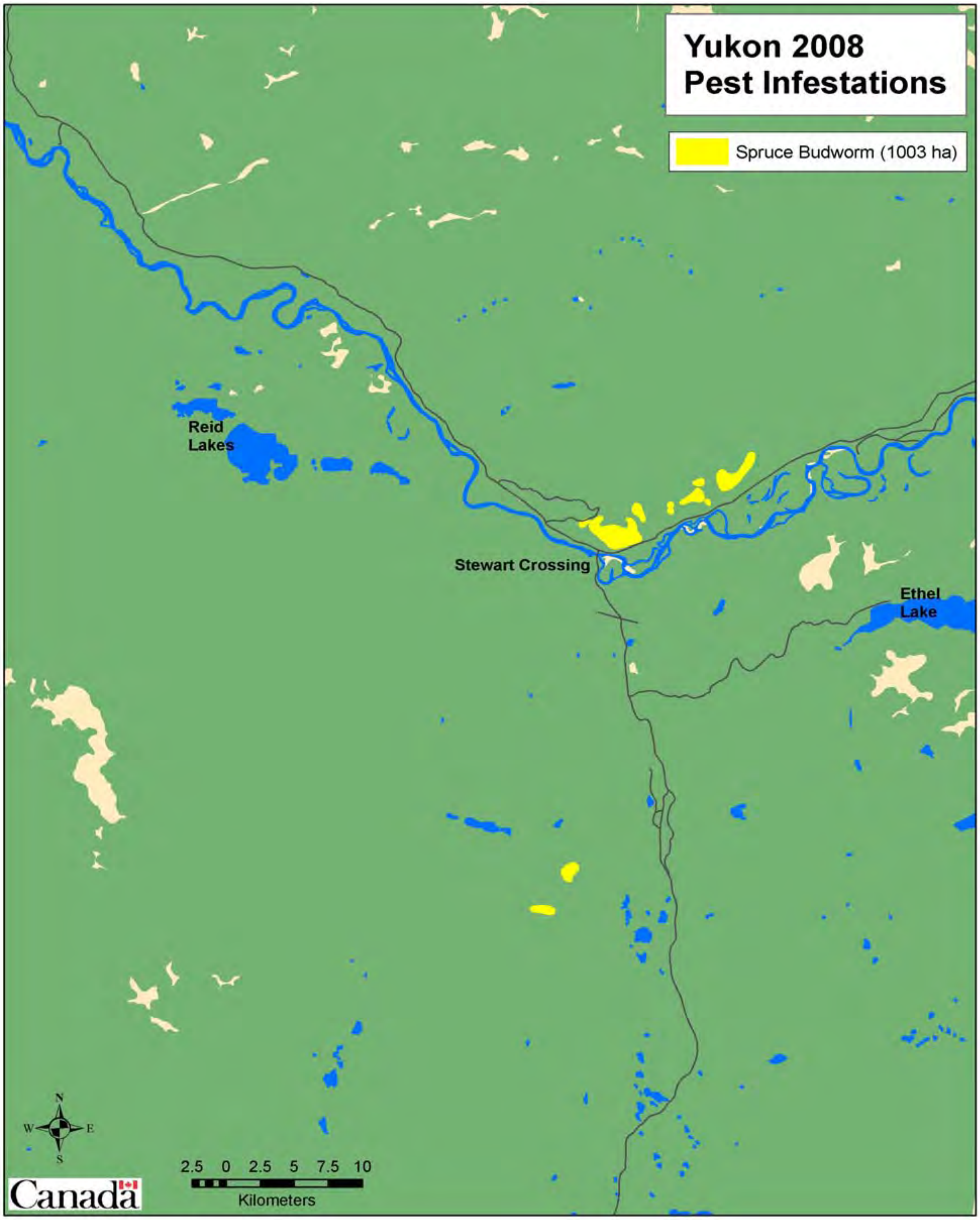


Photo 3. Spruce defoliation along the Peel River, 2007 (B. Decker, Hay River NWT)

However, when trapping was repeated in 2008 (though at five sites rather than six) in an attempt to verify the earlier findings, the results were significantly different: the southern two sets of traps attracted far more moths to the *C. biennis* bait (Table 3) while the northern three sets attracted more to the *C. orae* bait. This result was entirely unexpected and served to emphasize our lack of understanding of the finer points of budworm speciation and distribution in this little-studied region. Although these budworms have been assigned individual species names, they readily hybridize in the laboratory (Dr. Vince Nealis pers. com.). The criteria for species distinction have been twofold. First is the observation that each is attracted to a different pheromone formulation and, second, historically, the species were thought to have been geographically separated, with *C. orae* occurring primarily in coastal areas and *C. biennis* in the interior. The geographic separation of the species, however was brought into question in the early 1990s by an extensive trapping study throughout the northwest including the Yukon, British Columbia, Alaska and the Northwest Territories (Shepherd et al, 1995). As part of the study, both pheromone configurations were deployed at each of 10 sites throughout the southern Yukon. Significantly, moths were attracted to the *C. orae* bait at all of the 10 locations. Two of the sites, Haines Junction and Beaver Creek, bracketed the current study area. At Haines Junction, moths were attracted to both baits but the Beaver Creek traps caught only *C. orae*. This loosely corresponds to our recent study with *C. biennis* predominating in the south and *C. orae* in the north. Since both species seem to adhere predominantly to a synchronized two-year cycle, it is likely that some hybridization is occurring, especially in the Burwash area where one species yields dominance to the other.

These results present more questions than answers regarding budworm speciation and distribution. There is need for continued investigation including further pheromone work as well as the collection and rearing of larvae from throughout the area between Haines Junction and Beaver Creek. Populations of both species appear recently to be much more successful than they have been in the past, and, if this trend continues they may become significant defoliators of white spruce in the near future.

Table 3. Numbers of budworm in traps

Location	Geographic co-ordinates	Species		Ratio	Northward progression (km) from Congdon Cr.
		C. biennis	*C. orae*		
Congden Creek	07 630730 6781348	75.2	7.8	9.6:1	0
Nines Creek	07 623906 6787919	154.3	18	8.6:1	5.75
Duke River	07 599848 6805286	41.3	263.2	1:6.4	22.5
Quill Creek.	07 589256 6823641	34.2	351.3	1:10.3	40.2
Donjek River	07 559595 6844406	3.3	451	1:136.7	63

Flood damage

Flooding killed most of the white spruce in a Yukon Territorial campground at Tagish. The flooding must have occurred in the spring when the snow melted and a high water table throughout the early summer prevented the waters from draining back into the Tagish River. When seen in late July most of the water had recently receded and the ground was carpeted with red needles from the dying trees (Photo 4). The susceptible host material had attracted a local population of the engraver beetle, *Ips perturbatus.* Fortunately this population was not large and only a small number of the trees had been attacked. When the assessment was done in late July, the attacked trees contained high numbers of mature larvae and represented a significant population increase. At that time many trees were continuing to die. These trees will remain susceptible to attack through 2009 and represent a threat of significant escalation of the infestation. In an effort to forestall this, Forest Management Branch in Whitehorse in conjunction with Yukon Parks to remove the remaining susceptible trees during the winter.

Photo 4. Flood damage in campground at Tagish

Pine pests

Pine needle cast*, Lophodermella concolor*

This needle disease is the most common cause of pre-mature needle loss inYukon lodgepole pine. This year, in addition to the chronically infected stands around Watson Lake, needle cast caused significant damage in young stands near Minto at the south end of Minto Flats.   Where the damage was severe it was mapped from the air in late July over an area of 477 ha (Map 4). Lighter damage occurred over a much larger area.

The disease only becomes apparent on year-old needles when they turn red in the late spring (Photo 5). In the early summer, fruiting bodies of the fungus mature on the needles and spores can are then transferred to the adjacent current year's needles, thus ensuring the continuation of the infection. The main mode of transmission is rain splash and for this reason chronic infection tends to occur more frequently in the wetter southeast. However, two successive wetter than normal summers have promoted infection in areas where the disease is not normally seen. In areas of chronic severe infection, only needles produced in the current year remain at the branch tips, leading to the characteristic "lions tail" appearance. In older trees, the disease causes negligible damage because infected needles represent a small proportion of the entire crown. In younger trees such as those at Minto however, a much higher proportion of the photosynthetic capacity was lost. This will have resulted in a significant loss of current growth potential.

Photo 5. Pine needle cast at Minto flats

Pine engraver beetle, *Ips pini*

This beetle commonly attacks stressed and recently-killed pine. At Km 10.3 of the Kusawa Lake Road three mature pine had been girdled with a chainsaw in late 2006 or early 2007, presumably to kill and dry them in preparation for harvest for firewood. The dying trees had been attacked by *Ips pini*. Broods from these trees emerged last fall to over-winter in the duff and, this spring, attacked and killed an additional seven trees. Photo 6 taken in late July shows the characteristic pine engraver gallery pattern and numerous pupae. Infestations like this are common where industrial activity provides host material.

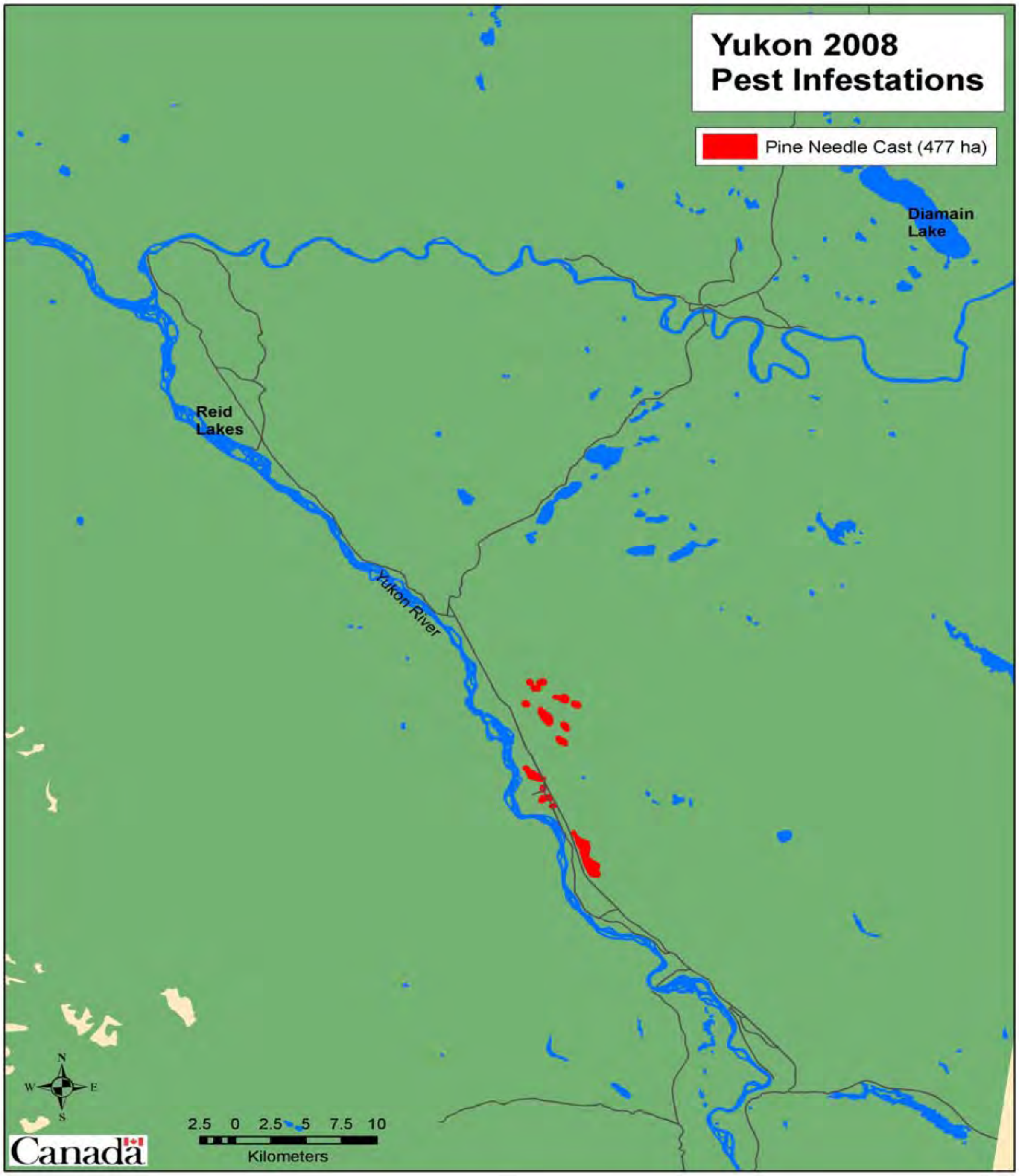
This area will be closely monitored in 2009. If the infestation continues to escalate it may be necessary to remove and dispose of infested trees.

Photo 6. *Ips pini* galleries with pupae

Roadside mortality

About 50 km north of Whitehorse, a group of 10 recently-killed mature lodgepole pine were seen adjacent to the north Klondike Highway. Three of the trees had been attacked by *Ips pini* and two others contained the lodgepole pine beetle, *Dendroctonus murrayanae*. An additional tree was 70% girdled by porcupine. The beetle attacks were seen more to be secondary effects of some other stressor, possibly related to their proximity to the highway. The trees may have been affected by prolonged exposure to a high water table or killed by the same stressor or group of stressors that have caused ongoing roadside tree death beside all of Yukon's major highways since the 1970s. This phenomenon, which indiscriminately affects all species of tree and woody shrub, has been discussed by experts and mentioned repeatedly in past reports, but speculation that it may be related to road salt, dust abatement chemicals (dating from before they were paved), the wind tunnel effect of the highway corridor, or all of the above, is ongoing.

Map 4. Areas where pine needle cast was mapped from the air



. **Deciduous Pests**

Aspen serpentine leafminer, *Phyllocnistis populiella*

Varying levels of leafmining damage were seen in aspen stands throughout surveyed areas in the Yukon again in 2008. In areas of concentrated activity balsam poplar leaves were also mined. As in prior years the most severe damage was in stands between Stewart Crossing and Dawson City and along the Silver Trail to Mayo. Farther south almost every examined aspen stand was infested but the damage was lighter with scattered pockets where severe feeding had resulted in the "silvering" of the leaves. For those who cannot remember what a normal aspen branch looks like I enclose Photo 7, taken along Windy Arm south of Carcross.

It is apparent from the persistence of this infestation that the specialized cadre of parasites, predators and diseases that ordinarily proliferate along with the leafminer and limit the success of populations are much less common in the Yukon. This is the longest running continuous infestation ever observed by this surveyor and it is clear that further research is needed for an understanding of the leafminer's success.

Photo 7. A rare aspen, unattacked by serpentine leafminer

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Willow blotch miner, *Micrurapteryx salicifoliella*

Defoliation of willow shrubs first reported last year was more widespread and severe in 2008. The damage became obvious in early July when the progression of damage within the leaf from insect feeding, causes it to die and turn red. Like last year the most severe infestations were in areas where willow proliferates in marshes and along the edges of water courses. The most severe infestations were seen along the Stewart and Yukon rivers (Photo 8). Many of the islands in the Yukon River upstream from Dawson City are densely overgrown with willow. The most severe patches were mapped over a total area of   38 ha (Map 2) during an aerial survey in July between Dawson City and Ballerat Creek.

Photo 8. Discoloured willow on island in the Yukon River

Spruce broom rust, *Chrysomyxa arctosyaphyli*

This rust is a common and chronic disease affecting white spruce wherever the alternate host kinnikinnik (*Arctostaphylos uva-ursi*) grows. Kinnikinnik favours dry rocky and well drained sites and the incidence of the disease is confined to these areas. However such sites are commonly found throughout south and central Yukon and the disease can be found almost everywhere they occur. The rust forms conspicuous brooms anywhere within the tree crown (Photo). The brooms grow over time and often achieve a diameter of one meter or more. In some areas almost every tree supports at least one broom. Some trees can have as many as 10.

Photo 9. Spruce broom rust

Spruce Brooms are often associated with stem deformations, reduced growth, dead or broken tops and tree mortality (Allen et al 1996). After tomentosus root disease, *Inonotus tomentosus*, it is the most serious disease affecting spruce in Yukon.

Large-spored Spruce – Labrador tea rust, *Chrysomyxa ledicola*

This common rust infected the current year's needles of white spruce at various locations throughout the southern Yukon in 2008. The infections became evident in mid-July as the rust pustules matured on the spruce needles. The incidence of this rust is limited to areas where the alternate host Labrador tea (*Ledum groenlandicum*) and, to a lesser extent, Northern Labrador tea (*Ledum palustre*) grow. As is typical for rust a disease, distinct parts of its life cycle are spent on the two host. White spruce is the aecial host (so named because the rust spore are borne on fruiting structures called aecia) and Labrador tea the telial host. Though the presence of Labrador tea is necessary for spruce to be affected the disease can survive on Labrador tea in the absence of spruce (Allen et al 1996). Both species of Labrador tea typically grow on wet and boggy sites and the incidences of infection were confined to these areas.

Infected needles (Photo 10 - opposite) subsequently died and were shed from the tree. The proliferation of the disease was aided by two successive cool moist summers, though the high incidences seen this year were unusual. Younger trees tend to be infected most often because of higher moisture levels close to the ground and a closer proximity to the low growing alternate host. The loss of current needles in these younger trees is significant because they constitute a higher proportion of the entire crown. Successive years of infection could lead to significant loss of growth potential, though trees are rarely killed.

Fire Smart

The Fire Smart program was introduced five years ago to Yukon communities, particularly those affected by the spruce beetle epidemic, as a means of mitigating the fire hazard. Selected stands were thinned to a three meter spacing between crowns and all ground fuels were removed. Knowing that the radical thinning would induce stress on the remaining trees I wanted to see what effect this would have with regard to pest activity, so, four years ago I began to survey selected Fire Smart sites around Haines Junction. In the first two years there were some spruce beetle and Ips attacks at three of the sites, one adjacent to the Yukon Forest Management Fire Centre, one beside the Parks Canada Visitor Centre and the other across the road from the water tower. After two years the mortality totaled less than 1% of the remaining trees in the stands and I concluded that the stress had little or no adverse effect on the tree's susceptibility to attack. No attacks have been seen in the past two years. I was asked this year to look at a recent Fire Smart project at Canyon because many of the trees were reported to be dying. In late July myself, Rob Legare of Yukon Forest Management and Dr. Bob Ott of RAO Ecological Consulting Services made a site visit to determine the cause of the mortality. About half of the white spruce over an area of about one hectare were either dead or dying. Significantly, none had been attacked by any of the host of secondary bark beetles that would normally be attracted to the large number of susceptible host available on the site. The bark on some of the trees was clearly charred from the numerous on-site fires that were lit last fall to consume the slash (Photo

11). We concluded from this direct evidence and the proximity of the fires to the trees that they alone were responsible for the problem. The fires must have been extremely hot and likely radiated outward in the duff to scorch the fine feeder roots of adjacent trees.

About 300 meters from this site on the eastern edge of the project three trees were currently attacked by *Ips perturbatus*. All trees supported high populations of mid-instar larvae. No obvious reason was seen for the attacks apart from their location on the edge of the thinning project.

Photo 11. Fire-scorched tree in Fire Smart site at Canyon

References

Shepherd R.F., T.G. Grey, and G.T. Harvey. Geographic Distribution of *Choristoneura* species (Lepidoptera: Tortricidae) feeding on *Abies, Picea* and *Pseudotsuga* in Western Canada and Alaska. 1995. The Canadian Entomologist 127: 813-830.

Yukon Forest Health Report 2008 Supplement

Trip Report
for the
2008 Yukon Forest Health Survey

Insects

Diseases

Abiotic Factors

Human Activities

Prepared by:
Robert A. Ott, Ph.D.
October 2008

From July 16-28, 2008, Robert Ott (RAO Ecological Consulting Services) assisted Rod Garbutt (Forest Health Technician, Canadian Forest Service) and Rob Legare (Silviculturist, Yukon Government) with the 2008 Yukon forest health survey. The intent of R. Ott's participation in the forest health survey was to become familiar with forest health issues, forest health survey techniques, forest types, and Permanent Sample Plot (PSP) sampling protocol in the Yukon. Knowledge of forest health-related issues in the Yukon will be used by R. Ott to assist the Yukon Government with its goal of developing a forest health risk assessment for the territory. This report summarizes the highlights of the activities in which R. Ott was involved as part of the 2008 Yukon forest health survey.

Forest Health Survey Areas

Forest health conditions were observed along much of the road system traversing forested landscapes in the Yukon. Notes were made regarding locations and types of forest health issues along road corridors. When necessary, site inspections were conducted to determine causal agents of tree mortality, to survey for forest health concerns that could not be observed from a moving vehicle (e.g. larch sawfly, *Pristiphora erichsonii*, egg niches), to collect samples of unknown insects and pathogens, and to take representative photographs. These road surveys or "windshield surveys" are logistically simple, cost effective, and they allow identification of forest health problems at a smaller scale and in earlier stages of development compared to aerial surveys. However, road surveys do not allow for identification of forest health concerns beyond what can be viewed from a road corridor, and estimates of the amount of land area affected by a forest health problem can not be calculated. Road surveys were conducted along the following highways and major roads:

- The Alaska Highway from Haines Junction south to Watson Lake near the British Columbia border;
- The North Klondike Highway from Whitehorse to Dawson City;
- The Silver Trail from Stewart Crossing to Mayo;
- The Robert Campbell Highway from its junction with the North Klondike Highway to Little Salmon;
- The Sough Klondike Highway from its junction with the Alaska Highway to the British Columbia border;
- Tagish Road from Carcross to Jakes Corner; and
- The Dempster Highway from its junction with the North Klondike Highway to kilometer 225 (north of the Ogilvie Mountains).

Some local roads were also surveyed for forest health problems. These included:

- Annie Lake Road located off the South Klondike Highway between the Alaska Highway and Carcross;
- Montana Mountain Road near Carcross;
- Scout Lake Road, Fish Lake Road, Jackson Lake Road, and Long Lake Road located in the vicinity of Whitehorse;
- Kusawa Lake Road located off the Alaska Highway east of Champagne; and
- Coal Lake Road and Barney Lake Road off the Alaska Highway near the Coal River near the British Columbia border.

Aerial forest health surveys also were conducted over several areas of the Yukon. Aerial surveys were conducted to map and investigate specific forest health problems, and not to map all forest health problems along a flight line. During these surveys, areas that were impacted by an insect of concern were designated by points and polygons on topographic maps (Rod Garbutt mapped the insect outbreaks). Aerial surveys work well for mapping large land areas, especially if they are inaccessible by other means of transportation. Also, when polygons of affected land areas are designated (as opposed to point locations), aerial surveys allow for the calculation of land area affected by a forest health problem. Compared to road surveys, aerial surveys can be more logistically complicated (e.g. bad weather, scheduling pilots), more expensive, and they do not work well to identify forest health problems that are small in scale or in the early stages of development. Aerial forest health surveys included:

- On July 17, a full day of helicopter aerial survey was conducted along the Yukon River and adjacent uplands and tributaries from Dawson City south to Ballarat Creek. This survey was conducted to investigate and map extensive mortality of white spruce (*Picea glauca*) trees in the area.
- On July 24, three hours of aerial survey from a fixed-wing aircraft was conducted to map current spruce beetle (*Dendroctonus rufipennis*) infestation in the vicinity of Haines Junction. The survey was conducted south and east of Haines Junction, and included the Shakwak Valley from Haines Junction to Kusawa Lake, the area around Kathleen Lakes, the Klukshu River Valley south of Dezadeash Lake, the west side of Kusawa Lake from Ark Mountain north to its outlet at the Takhini River, the Takhini River from Kusawa Lake north to the Alaska Highway, the valley containing Jo-Jo Lake, the Mendenhall River from the Takhini River to Taye Lake, and the Dezadeash River Valley (and Alaska Highway) from the Takhini River west to Haines Junction.
- On July 26, four hours of aerial survey from a fixed-wing aircraft was conducted to continue mapping current spruce beetle infestation in the vicinity of Haines Junction. The survey was conducted north, east, and northwest of Haines Junction and included the Aishihik River Valley from the Alaska Highway north to its junction with the West Aishihik River, the West Aishihik River Valley, areas around Bear Lakes and Sekulmun Lake, Isaac Creek Valley and then west over the Ruby Range to the east side of Kluane Lake and Talbot Arm, and southeast over the Shakwak Valley and Kloo Lake back to Haines Junction.
- On July 28, four hours of aerial survey from a fixed-wing aircraft was conducted west of the North Klondike Highway from Whitehorse north to Stewart Crossing, along the hills north of the Silver Trail from Stewart Crossing to Mayo, and east of the North Klondike Highway from Stewart Crossing south to Whitehorse. The primary intent of the aerial survey was to map the extent of a spruce budworm (*Choristoneura* spp.) infestation in white spruce forests in the hills north of the Silver Trail. In addition, we wanted to determine if a pine needle cast (likely *lophodermella concolor*) infestation in young lodgepole pine (*Pinus contorta*) stands near Minto Landing was visible from the air.

Insects

Spruce beetle (*Dendroctonus rufipennis*; primarily attacks white spruce)—The only significant spruce beetle activity that was observed was in the southwest Yukon, where an 18 year outbreak continues. Large expanses of the forested area that was surveyed in the vicinity of Haines Junction consisted of dead white spruce trees (Photo 1). However, large areas of forest within the perimeter of the spruce beetle outbreak also consisted of a matrix of live and dead white spruce trees (Photo 2). Throughout the survey area, pockets of recent spruce beetle infestation—as indicated by white spruce trees with dead foliage that was red in color (Photo 3)—were noted and designated on topographic maps. Within the survey area, the spruce beetle outbreak was extensive along the northwest edge of the Kluane Ranges of the St. Elias Mountains, extending into the Shakwak Valley, across the Ruby Range, and into the West Aishihik River Valley. The eastern perimeter of the spruce beetle outbreak was in the vicinity of the Mendenhall River and Taye Lake.

Photo 1. White spruce forest along the Haines Road near Klukshu that has been killed by the ongoing spruce beetle outbreak in the southwest Yukon.

Photo 2. Large areas of white spruce forest within the perimeter of the spruce beetle outbreak consists of a matrix of live and dead trees, such as this forest at the outlet of Pine Lake near Haines Junction.

Photo 3. White spruce trees in the red phase, indicative of recent mortality due to infestation by spruce beetles (northern spruce engraver beetles also are attacking some spruce, especially smaller ones—R. Garbutt, pers. commun.).

Northern spruce engraver beetle (*Ips perturbatus*; primarily attacks white spruce)—The most significant northern spruce engraver beetle activity that was observed was during the aerial survey along the Yukon River south of Dawson City. Extensive white spruce mortality had been reported in the area (Photo 4), and the concern was that the spruce beetle infestation in the southwest Yukon had moved up the White River Valley and into the Yukon River Valley (R. Garbutt, pers. commun.). White spruce mortality ranged from single trees to about 2 ha in size, and was present in both river floodplains and in adjacent uplands.

Site visits during the aerial survey confirmed that spruce mortality was due mostly to northern spruce engraver beetles, allaying concerns that the mortality was due to an expansion of the spruce beetle outbreak. Spruce beetles were present, but their activity was limited to the bottom one meter of infested trees, and infestation levels were low. Some larger areas of spruce mortality in the floodplains were believed to be caused from a high water table, and not from bark beetle activity. Spruce engraver beetle infestation levels were high in the spruce trees that were attacked in the summer of 2007 (Photo 5), and resulted in the death of the trees. However, emergence of adult beetles in 2007 was low. As a result, current beetle brood levels were also low, and the northern spruce engraver outbreak is anticipated to subside.

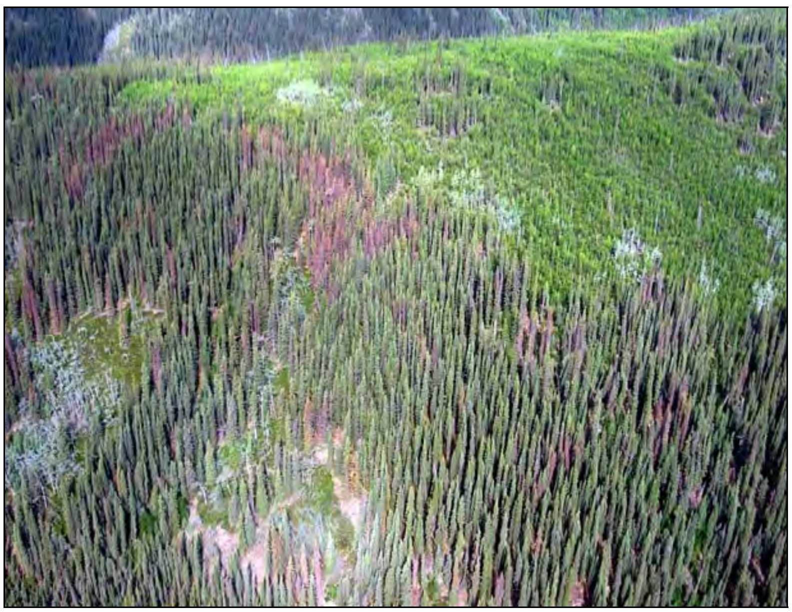

Photo 4. White spruce trees recently killed by northern spruce engraver beetles in the uplands along the Yukon River. Mortality of spruce trees from engraver beetles was extensive in the survey area along the Yukon River from Dawson City, south to Ballarat Creek. Spruce beetles also attacked the trees, but they were not the primary mortality agent.

Photo 5. Intensive infestation of northern spruce engraver beetles overwhelms the defensive mechanisms of white spruce trees. Egg galleries (made by adult beetles) and larval feeding on on the phloem effectively girdle the the trees, resulting in death.

Elevated northern spruce engraver beetle activity also was noted along the first 5 km of the Silver Trail near Stewart Crossing. The elevated engraver beetle population in this area is believed to be a result of powerline clearing that was conducted along the Silver Trail several years ago (R. Garbutt, R. Legare, pers. commun.).

Pine engraver (*Ips pini;* attacks lodgepole pine)—Pine engraver activity was at endemic levels throughout the survey area. Most pine engraver activity was associated with porcupine feeding damage (see the section on Porcupine Feeding Damage for a more detailed discussion). Pine engravers also were noted to be infesting and breeding in pine trees that had been cut down and left in the forest along Long Lake Road near Whitehorse, and in windblown pines at Kusawa Lake (Photos 6 and 7).

Photo 6. Frass piles (i.e. boring dust) on a lodgepole pine log, indicative of infestation by pine engraver beetles.

Photo 7. Egg and larval galleries of pine engraver beetles. Note the adult beetle near the nuptial chamber in the center of the picture, and another in an egg gallery at the top of the picture.

Spruce budworm (*Choristoneura* spp.; feeds primarily on white spruce)—During a road survey, some localized spruce budworm feeding damage was noted along the Silver Trail between Stewart Crossing and Mayo. A site visit yielded noticeable damage to new spruce growth caused by budworm larval feeding (Photo 8), as well as adult spruce budworm moths (Photo 9). Upon further inspection, a small spruce budworm outbreak was identified on the south side of the ridge that extends from Stewart Crossing to Mayo on the north side of the Silver Trail (Photo 10). Budworm feeding damage was extensive along the 8-9 km of the ridge nearest Stewart Crossing. During the follow-up aerial survey on July 28, it was determined that the budworm outbreak was restricted to this ridge on the north side of the Silver Trail.

Photo 8. Feeding damage to new foliage by spruce budworm larvae.

Photo 9. Adult spruce budworm moth on a white spruce tree adjacent to the Silver Trail.

Photo 10. Extensive spruce budworm feeding damage (red branch tips) in white spruce trees on a hillside with a southerly aspect on the north side of the Silver Trail.

Aspen leafminer (*Phyllocnistis populiella*)—The aspen leafminer outbreak, caused by larval feeding damage (Photo 11), extended across the Yukon in quaking aspen (*Populus tremuloides*) trees (Photo 12) as well as in balsam poplar (*Populus balsamifera*). Within the survey areas, only quaking aspen stands near treeline lacked leaf miner damage.

Photo 11. Feeding damage of aspen leafminer larvae.

Photo 12. Extensive aspen leafminer feeding damage in upland aspen stands adjacent to the Yukon River south of Dawson City.

Willow leaf blotch miner (*Micrurapteryx salicifolliela*; feeds on multiple species of willow, *Salix* spp.)—Within the survey area, defoliation by the willow leaf blotch miner (Photo 13) was extensive along the North Klondike Highway from Carmacks to Dawson City; along the Robert Campbell Highway from its junction with the North Klondike Highway to Little Salmon; along the Silver Trail from Stewart Crossing to Mayo; along lower elevations of the Dempster Highway; and along Montana Mountain Road near Carcross. The apparent absence of the willow leaf blotch miner along other portions of highways, at least north of Jake's Crossing, was likely due to a lack of willows along portions of the road corridors. During aerial surveys, it was noted that willow leaf blotch miner was extensive in the floodplain the Yukon River (Photo 14) from Dawson City south to Ballarat Creek, and in the floodplains of the Stewart River and Pelly River. Short growing seasons and low temperatures in the alpine areas along the Dempster Highway likely explain the lack of willow leaf blotch miner in alpine willow stands in the Ogilvie Mountains.

Photo 13. Feeding damage of willow leaf blotch. miner.

Photo 14. A willow stand in the Yukon River floodplain exhibiting intensive feeding damage from the willow leaf blotch miner. Also note the dead white spruce due to a northern spruce engraver beetle outbreak.

Larch sawfly (Pristiphora erichsonii)—A stand of eastern larch (*Larix laricina*) at kilometer 225 of the Dempster Highway, north of the Ogilvie Mountains, was inspected for larch sawfly egg niches and feeding damage (Photo 15). No evidence of larch sawfly was observed. This larch stand was identified as a survey site because of past larch sawfly activity.

Photo 15. Rod Garbutt examining larch seedlings for larch sawfly egg niches and feeding damage.

Unidentified web-spinning defoliator—An unidentified species of web-spinning defoliator was found on the underside of branches of subalpine fir (*Abies lasiocarpa*) on Montana Mountain near Carcross (Photo 16). Defoliating larvae were about 1 cm long, light green in color, had a brown head, were prominently segmented, and were social (i.e. a number of larvae were residing within the webbing). This defoliating insect was also observed on nearby white spruce.

Photo 16. Unknown species of defoliator larva and its webbing located on the underside of a subalpine fir branch on Montana Mountain near Carcross. Also note the presence of fir rust on the needles (lower right).

Diseases

Pine needle cast—Pine needle cast is a fungal pathogen that results in lodgepole pine trees dropping their needles. The pine needle cast that was observed was likely *lophodermella concolor*, (R. Garbutt, pers. comm.) although a conclusive identification was not established in the field. Pine needles infected the previous year turn red in early summer as needle necrosis takes place (Photo 17)—infestations are very apparent during this time. As the infestation progresses, needles turn straw-colored, and the infected needles eventually fall from the tree (Photo 18)—infestations are less apparent during these later stages.

Photo 17. Lodgepole pine needles infected with pine needle cast. Needles infected the previous year turn red in early summer, and are highly visible.

Photo 18. As summer progresses, pine needles infected with pine needle cast turn straw-colored and are shed. New growth remains green, giving the tree branches the appearance of a lion's tail.

Pine needle cast was extensive in young pine stands (sapling stage) in the Minto Flats-McCabe Creek area, and in both saplings and mature trees along the Alaska Highway from the Continental Divide south to the British Columbia border. Part of the infestation in the Minto Flats-McCabe Creek area was visible enough to be mapped from the air on July 28 (Photo 19), even though the infestation was advanced and needles were dropping from the trees (as observed during a site inspection on July 20).

Photo 19. A stand of young lodgepole pine infected with pine needle cast in the vicinity of Minto Flats and McCabe Creek along the North Klondike Highway.

Large-spored spruce-Labrador tea rust (*Chrysomyxa ledicola*)—This needle rust fungus affects spruce trees in areas where the alternate host, Labrador tea (*Ledum palustre* and *L. groenlandiculum*) also occurs. It grows on current years' needles on spruce trees. A diagnostic feature is that it is the only rust that produces uredinia ("mass of hyphae and spores of a rust fungus forming pustules that rupture the host's cuticle" [Merriam-Webster Online Dictionary]) on the upper surface of its alternate host, Labrador tea (Photo 20).

Photo 20. A diagnostic feature of large-spored-Labrador tea rust is the presence of uredinia (seen as red and grey spots) on the upper surface of Labrador tea, the alternate host for this rust species.

Large-spored spruce-Labrador tea rust was observed in localized patches along Long Lake Road (km 18) near Whitehorse (Photo 21), and along the Alaska Highway near the Morley River.

Photo 21. White spruce seedlings infected with large-spored spruce-Labrador tea rust along Long Lake Road near Whitehorse. Labrador tea, the alternate host for this rust species, can be seen growing in the forest understory.

Fir rust—A rust fungus was observed on this year's needles of subalpine fir trees on Montana Mountain near Carcross. Although the rust was not positively identified, it was most likely fir broom rust (*Melampsorella caryophyllacearum*) or fir-fireweed rust (*Pucciniastrum epilobii*) (R. Garbutt, pers. commun.).

Willow rust (*Melampsora epitea)*—Currently, all rust fungi that occur on willow (*Salix* spp.) in North America are grouped in one species complex, ***Melampsora epitea*** (Smith et al. 2004). Willow rust (Photos 22 and 23) was observed throughout the regions of the Yukon that were observed during the forest health survey. It was especially common along Fish Lake Road (off the Alaska Highway south of Whitehorse).

Photos 22 and 23. All rust fungi that occur on willow in North America are grouped in ones species complex, *Melampsora epitea*.

Abiotic Factors / Forest Decline

Aspen dieback—Aspen stands exhibiting dieback were scattered along the North Klondike Highway between Whitehorse and Stewart Crossing. Most of these stands were on dry, rocky slopes and bluffs, with south and west aspects, although some stands were located on level ground with gravelly, well-drained soil. Aspen stands experiencing dieback tended to be open-canopied and were often stunted. Those on the rocky slopes and bluffs typically were adjacent to treeless steppe plant communities which are found on sites too dry for trees to grow. These transitional aspen stands between steppe and closed-canopy forest often die back following dry weather (Chapin et al. 2006).

A site visit was conducted in a transitional aspen stand exhibiting dieback (extensive tree mortality and crown thinning, Photo 24) along Tagish Road about 15 km northeast of Carcross.

The aspen stand was located at the base of a treeless bluff on a steep, rocky hillside with a southeast aspect (Photo 25). The understory vegetation in the aspen stand consisted primarily of kinnikinnick (*Acrtostaphylos uva-ursi*) and common juniper (*Juniperus communis*), both of which are indicator plants of dry sites. No obvious insect damage explained the aspen dieback. Some black canker (*Ceratocystis fimbriata)* was observed, but it was not extensive or severe enough to explain the extensive dieback. External indicators of heart rot, such as aspen trunk rot (*Phellinus tremulae*) were not observed, but some heart rot could have been present. In contrast to the transitional aspen that were growing on a dry, steep slope and exhibiting dieback, the aspen trees further down the hill (below Tagish Road) were growing on a gentler slope and were green and healthy (Photo 25). The proximity of the dead and dying aspen to the dry bluff, and the vigor of the aspen further downhill on a gentler slope, suggests the declining trees are drought-stressed. Other stress factors, however, may also be involved in causing tree decline.

Photo 24. Close-up view of dead and dying aspen trees at the base of the dry bluff shown in Photo 25. Insect-related mortality or substantial disease was not evident, suggesting that they were not the primary cause of tree mortality and decline in this stand of trees.

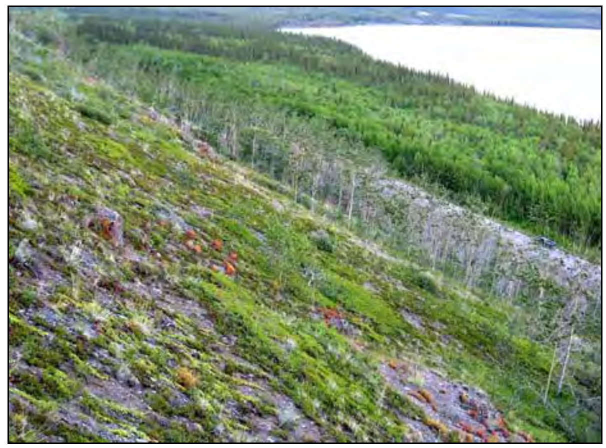

Photo 25. Aspen trees at the base of this dry, treeless, southeast-facing bluff along the Tagish Road are dead and/or in decline, while aspen trees below the road are green and healthy. The proximity of the dead and dying aspen to the dry bluff, and the vigor of the aspen further down the slope, suggests the declining trees are drought-stressed.

Another aspen stand that was exhibiting dieback was examined along Scout Lake Road near Whitehorse. The aspen stand was located on a small, dry, hillside with a southerly aspect. On top of the hill, above the aspen stand, was a treeless knob, dominated by sage (*Artemesia* spp.) and grasses. Live aspen trees were stunted and distorted, with numerous dead tops (Photo 26), and numerous dead, standing trees were present.

The dead and dying trees had basal wounds on the downhill side, with numerous bore holes from poplar borers (*Saperda calcarata*) (R. Garbutt, pers. commun.). Boring frass was not present, indicating the bore holes were not recent (Photo 27). A live aspen tree with poplar borer damage was sampled (Photo 28). No root rot or heart rot was present, but most of the wood column at the base was stained. Larval galleries of the poplar borers did not extent deeply into the tree. It is unclear whether the poplar borer infestation itself resulted in the dieback of this aspen stand, or if of other stressors such as drought are also factors in the decline.

Photo 26. Aspen stand in decline on a dry, southerly-facing hillside along Scout Lake Road near Whitehorse. Trees had basal wounds with bore holes from poplar borers. Tree decline may have been induced by the wood-borers, but decline from multiple stressors (e.g. drought, insects) is also possible.

Photo 27. Non-recent (i.e. no boring frass) bore holes from poplar borers, a species of long-horned beetle. All boring damage was at the base of trees on the downhill side.

Photo 28. Cross-section of an aspen tree showing damage from poplar borers on the left side of the picture. Galleries packed with frass are evident.

Flooding—A site visit was conducted in a forested area between the Tagish River Bridge and the Tagish Campground on the south side of the Tagish Road. The area had been recently flooded, as indicated by the lack of vegetation in low-lying areas near the Tagish River (Photo 29); by the standing water in low-lying areas in the Tagish Campground (Photo 30); and by the mortality of white spruce trees in all size classes, from saplings to sawlog-sized trees. The flooding is believed to have occurred during the spring or early summer of 2008, because large diameter white spruce were infested with adults and larvae of the northern spruce engraver beetle, and with eggs (Photo 31) and first year larvae of spruce beetles.

Numerous hazard trees have been created in the Tagish Campground as a result of the flooding and the resulting beetle infestion. In addition, the beetle infestation will likely result in local populations of northern spruce engraver beetles and spruce beetles to be elevated, resulting in infestation of neighboring, currently healthy white spruce trees. Therefore, it is recommended that hazard trees be removed from the campground, and that mitigation measures be taken to control local bark beetle populations.

Photo 29. Areas of low elevation near the Tagish River were flooded during the spring/summer of 2008. Low-lying areas that retained water did not have living vegetation (see photo), and trees of all size/age classes were dead and dying. Trees large enough to harbor bark beetles (such as the white spruce in the photo) were infested with spruce beetles and/or northern spruce engraver beetles, and other scolytids.

Photo 30. Low-lying areas in the Tagish Campground near the Tagish River had standing water from a spring/summer flood. Numerous white spruce trees in the campground were dead or dying, and likely infested with bark beetles. Hazard tree mitigation and bark beetle reduction measures are recommended to protect campground users and to minimize the impact of elevated bark beetle populations on neighboring spruce trees.

Photo 31. Spruce beetle egg gallery with eggs, in an infested white spruce tree that was stressed by local flooding from the Tagish River.

Porcupine Feeding Damage

Porcupine (*Erethizon dorsatum*) feeding damage, caused by bark gnawing to gain access to inner bark, was observed on individual trees throughout the forest health survey area. Most porcupine damage was observed on ponderosa pine. On younger (i.e. smaller diameters) pines, porcupine bark gnawing could occur throughout the length of the tree bole. In older (i.e. larger diameter) pines, park gnawing tended to be located in the upper portions of the tree boles. This feeding pattern occurs because porcupines prefer trees with thin, smooth bark (Olson and Lewis 1999), which translates into a preference for younger trees, or the younger portions (i.e. tops) of older trees. The stress caused by porcupine feeding damage on conifers often resulted in an attack by pine engraver beetles (in lodgepole pines) and other bark beetles, with subsequent mortality of the tree (Photo 32) or at least that portion of the tree above the porcupine wound.

Photo 32. Porcupine feeding damage at the base of this lodgepole pine stressed the tree and resulted in attack and death by bark beetles.

Outreach / Extension / Human Activities

Site visit to a private home—While in Dawson City, a follow up site visit was conducted at a private home in the West Dawson Subdivision, west of Dawson City across the Yukon River. During the initial site visit in October 2007, Rod Garbutt and Rob Legare found that northern spruce engraver beetles initially attacked and killed white spruce trees along the driveway and in the dog yard, and then spread to neighboring trees around the house. Spruce along the driveway were stressed and susceptible to beetle attack because fill material for the driveway was smothering tree roots. Spruce in the dog yard were stressed and susceptible to beetle attack because of high concentrations of dog urine and damage from tether chains. During the follow up visit, no evidence of recent (2008) beetle attacks was found. Few emergence holes from beetle-attacked trees led to the conclusion that spruce engraver beetle larvae/pupae did not reach maturity in the summer of 2007, although large numbers of beetle larvae resulted in the death of attacked trees. The cause of the decline in the beetle population was not determined.

Grizzly Lake Trail—At the request of Yukon Parks, a site visit was conducted along a portion of the Grizzly Lake Trail in Tombstone Park along the Dempster Highway to look at patch of dead, large diameter, white spruce trees. The dead white spruce were located about 800 m from the trailhead. It was determined that the spruce mortality was due to a small localized spruce beetle infestation that was initiated by one or more small blowdown events (Photo 33). Most likely the trees were infested by a multi-generational event of spruce beetle in the area. No sign of the northern spruce engraver beetle was observed in the dead spruce. The site visited was followed by a short report to Yukon Parks staff (by Rob Legare), summarizing the observations made during the site visit, and providing information on mitigation techniques to control spruce beetle and spruce engraver beetle populations.

Photo 33. Root throw mound and root thrown white spruce trees as a result of a blowdown along the Grizzly Lake Trail. The blow-down allowed an endemic population of spruce beetles to increase in size and infest nearby live white spruce trees.

Mt. Siema Subdivision—A visit to the Mt. Siema Subdivision near Whitehorse was conducted to look for examples where homeowner activities may create or exacerbate forest health problems. There is much home construction in this new subdivision, with the associated driveway fill, cut and bull-dozed trees, and firewood piles.

Most of the immediate forest health concerns due to land clearing and home construction will be in white spruce and lodgepole pine forests, although human activities can also create forest health issues in deciduous forest stands. Of concern are any activities that create enough bark beetle brood material (i.e. food for larval beetles) to allow endemic populations of bark beetles to increase to outbreak levels. Bark beetle species of concern are the spruce beetle, the northern spruce engraver beetle, and the pine engraver beetle.

Cutting of live white spruce and lodgepole pine trees directly creates bark beetle brood material. If green trees and tops with a diameter greater than 10 cm (including firewood) are not removed from a site or quickly dried, bark beetles are likely to utilize the material and local populations can erupt and kill nearby trees (Photo 34). Stressed white spruce and lodgepole pine trees can also serve as brood material for bark beetles. Trees are often stressed during home construction activities either through direct physical damage (e.g. significant bark removal from heavy equipment) of by smothering the root systems with fill used to construct house pads and driveways (Photo 35).

Photo 34. New home construction in the Mt. Siema Subdivision near Whitehorse has the potential to create forest health problems for home owners. Green spruce and pine firewood stacked against standing live spruce and pine trees can result in localized bark beetle infestations.

Photo 35. Driveway fill (see photo) and gravel pads for home construction can smother tree roots. When roots of spruce and pines are smothered, the resulting stress typically attacks bark beetles, and a local infestation can ensue. Smothering roots of deciduous trees also can result in stress and death of trees, although infestation by bark beetles is less common than it is in spruce trees.

Shaded fuel break at Canyon Village—At the request of Aynslie Ogden (Forest Science Officer, Yukon government) a site visit was conducted at a shaded fuel break at Canyon Village. The concern was that bark beetles were attacking and killing the residual white spruce trees. It was determined that the dieback and mortality of the residual spruce trees was due to excessive heat from burning slash created during the construction of the fuel break and/or from burning slash piles too close to the residual trees (Photo 36). No evidence of bark beetles was found in the residual trees, and a single adult spruce beetle was found in a residual slash pile.

A shaded fuel break adjacent to the one with fire-damaged trees was also inspected. In this fuel break, only one scorched tree was observed, and no scorched tree crowns were identified (Photo 37).

Photo 36. Excessive heat from burning slash piles, and burning slash too close to residual trees, resulted in scorching of tree trunks and death of tree crowns in this shaded fuel break at Canyon Village.

Photo 37. This shaded fuel break is adjacent to the fuel break in Photo 36. Slash also was burned on site in this fuel break, but only one scorched tree was observed, and no scorched tree crowns were identified.

Powerline right-of-way clearing—Large slash piles from clearing a powerline right-of-way (ROW) during the summer of 2007 extended along a stretch of the North Klondike highway north of Stewart Crossing. Spruce and pine slash served as brood material for northern spruce engraver beetles and pine engravers respectively. Bark beetles emerging from those slash piles then infested some of the spruce and pine along the ROW (Photo 38).

Photo 38. Spruce/pine slash piles created during right-of-way clearing along the North Klondike Highway in the summer of 2007 became infested with bark beetles (northern spruce engravers, pine engravers). Adult beetles that emerged from the slash in 2007 overwintered in near-by duff and then attacked spruce and pine trees along the edge of the right-of-way in the summer of 2008 (dead trees can be seen in the back-ground).

Monitoring Plots

Permanent Sample Plots—The Permanent Sample Plot (PSP) program conducted by the Yukon Government's Forest Management Branch was discussed with Shirley Hill (Forest Management Technician, Yukon Government). The discussion took place at PSP #17, located in a lodgepole pine stand along Long Lake Road near Whitehorse. The potential use of PSPs for forest health monitoring will be discussed with the Forest Management Branch at a later date.

Forest health monitoring plots—Three forest health monitoring plots in the vicinity of Haines Junction (Photo 39) were visited with Rod Garbutt and Rob Legare (Photo 40). These plots were established by Rod Garbutt to monitor ecosystem response/recovery to the ongoing spruce beetle infestation in the southwest Yukon. Plot installation and data sampling protocol were reviewed.

Photo 39. Numbered trees in a forest health monitoring plot in the vicinity of Haines Junction.

Photo 40. Rob Legare (left) and Rod Garbutt (right) discuss data collection protocol for Rod's forest health monitoring plots in the vicinity of Haines Junction.

Plant Communities

While conducting the forest health survey, observations were made regarding plant community types and distributions. This information, along with vegetation classification maps, will be useful for the development of a forest health risk assessment for the Yukon.

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